NATIONAL PARK SERVICE
GREAT SMOKY MOUNTAINS NATIONAL PARK
BRIEFING STATEMENT
April, 2007

SUMMARY OF FOREST INSECT AND DISEASE IMPACTS

The forests of the Smokies are known for their diversity. Several species of forest insects and diseases introduced from other continents have found suitable habitat and tree hosts here. In the absence of genetic resistance and/or biological and environmental controls, these pests continue to cause serious damage. Others have not yet arrived but have the potential for future impact. Native forest pests may cause periodic episodes of tree mortality, but they rarely cause widespread ecological devastation.

Pest Species Currently Present in the Park:

Hemlock woolly adelgid (HWA)

This Asian relative of the balsam woolly adelgid was found in the park in 2002 and has rapidly spread throughout all areas of the park that contain hemlock. HWA was considered an unimportant pest on ornamental hemlocks when it was first discovered in the eastern US fifty years ago. It subsequently spread into natural forest stands throughout the mid-Atlantic states and has become one of the region's most serious forest insect problems, with infestations extending south into Georgia and north into New England. HWA attacks several species of hemlock, but eastern hemlock (*Tsuga canadensis*) is the only hemlock species found in the park. The insect is easily dispersed by birds and wind or infested horticultural material, and all sizes of hemlocks are vulnerable.

HWA feeds at the base of the tree's needles, reproducing prolifically and sometimes causing death in as little as two years. Insecticidal control is possible in landscape settings, but is difficult for natural stands. The park currently has a team dedicated to controlling HWA with insecticides and release of biological control insects. Biological control holds the best hope for long-term control of HWA at levels that will allow hemlock trees to survive. Early results of biological control, including several Asian species of beetles that feed exclusively on HWA, show promise. Nearly one million HWA predatory beetles have been released at over 500 sites from Maine to South Carolina. The virgin hemlock stands in the park are particularly vulnerable since they are aging and not vigorous; these stands are a high priority for biological controls. For more information about HWA as well as photographs visit the USDA Forest Service website at: http://na.fs.fed.us/fhp/hwa/

Recent vegetation mapping shows a large hemlock resource in the park. Nearly 1500 acres of old growth hemlock have been mapped with some trees in excess of 500 years old, six feet across and 160 feet tall. The park's total hemlock resource has been mapped at more than 137,000 acres with over 14,000 acres of hemlock-dominated forest. The hemlock forests provide unique habitat for plant and animal species including stream edge (riparian) species.

Stream habitat is influenced by hemlock and studies in Delaware Water Gap National Recreation Area have shown the importance of hemlock in moderating stream temperatures. In December, 2005 a Finding of No Significant Impact was prepared in response to the public scoping process and affected agency review of a draft environmental assessment (EA) of Hemlock Woolly Adelgid Control Strategies in GRSM. The EA offered five alternatives: No Treatment, No Action (no change from current level of treatment), Chemical Control Only, Biological Control Only, and Both Chemical and Biological Control. The option of "Both Chemical and Biological Control" was chosen as the Preferred Alternative.

Since 2002 the Park has released over 300,000 *Sasajiscymnus tsugae* (St) beetles as part of the overall control effort. Treatments in 2006 included releases of 65,000 St and 2500 *Laricobius nigrinus* (Ln) predator beetles and eggs. Over 360 acres were sprayed with insecticidal soap or oil treatments. Over 450 acres were treated with systemic insecticides. Early in 2007 the 50,000th hemlock was systemically treated. Treatments not only protect the park hemlock resource, but also protect the public from hazard trees caused by hemlock mortality. Tree removal is also much more expensive than treating trees. All backcountry campsites with overstory hemlock have been treated. Popular trails with overstory hemlock are being treated. Select old growth stands are being treated either by park employees or by contract. Heavily visited areas, such as campgrounds, picnic and historic areas are being retreated as needed since initial treatments began three years ago.

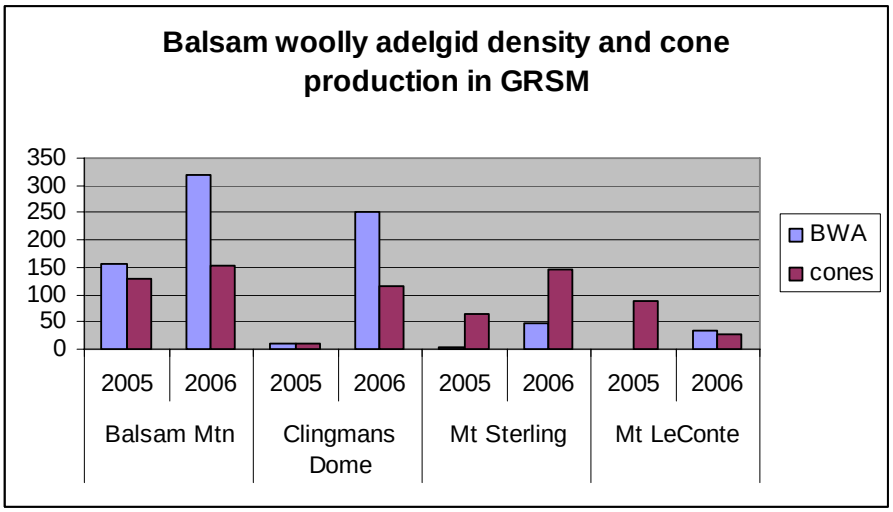
In 2005 nearly 100 monitoring plots were installed throughout the park to determine effectiveness of treatments, against plots receiving no treatment. Annual re-measurement of the plots is scheduled for years to come. Analysis of the data is showing a positive effect of the treatments compared to untreated. The biological controls are expected to take ten years or more to determine effectiveness. New biological controls for HWA are being screened by federal agencies and universities for host specificity and effectiveness.

Balsam woolly adelgid (BWA)

This insect from Europe has devastated the Fraser fir stands found at the park's highest elevations. Approximately 74% of all the spruce-fir forest type in the southern Appalachians is found in the Great Smoky Mountains. An estimated 91% of the park's mature firs have died since BWA was first discovered in 1962. Fraser fir has been listed as a candidate species of special concern, and the spruce-fir ecosystem is also at risk. Fraser fir is the primary host for several nationally and globally rare bryophytes (mosses and liverworts) and the fir forest is also essential habitat to the very rare spruce-fir moss spider, now listed as a federally endangered species.

Young fir are generally not attacked until they are large enough to produce roughened bark--approximately 20 years-- and this is also about the time they start to produce cones. In some areas fir reproduction is very good, resulting in dense stands of young, small firs, of which some may survive long enough to sustain at least a small population of mature firs. Some other sites are choked with blackberry and other competing shrubs. When population monitoring shows the need, park Resource Managers may treat mature fir with an insecticidal soap along Clingmans Dome road and summit, and along Balsam Mountain Road. Adelgid populations

have been low at Clingmans Dome for several years until 2006, while Balsam Mountain Road has supported populations that have been high enough to warrant soap treatments. BWA populations are also monitored on Mt. LeConte, Mt Guyot and Mt. Sterling.



The Fraser fir genetic preservation planting at Purchase Knob is doing well. In 1995, 600 Fraser fir seedlings, grown from seeds collected in the park, were planted on this recently donated property east of Cataloochee Divide. While some have become infested with BWA, they are annually monitored, and if needed, treated with the insecticidal soap or a dormant oil spray mix. The plantation is a cooperative effort between the park and the University of Tennessee (UT) Department of Forestry, Wildlife and Fisheries. The planted trees are managed as a reservoir of the park's Fraser fir genetic material.

Resistance to BWA may be found in the remnant stands of old fir that have somehow survived. Researchers at North Carolina State University have cooperated with the park in studies to determine mechanisms of resistance in bark chemistry. Some firs have elevated levels of plant hormones that may prevent BWA from completing its life cycle.

Dogwood anthracnose

The fungus known as dogwood anthracnose (*Discula destructiva)* was first found in the US at Chehalis, Washington, in 1977 and shortly thereafter in the New York City area. Recent DNA studies indicate that the fungus is an introduced pathogen. The fungus spread southward and was found in Maryland in 1983 and in north Georgia in late 1987. While the disease creates scattered mortality in landscape settings, it is most severe in the cool, moist areas, particularly in the understory, that characterize much of the tree's habitat in the park. Wet conditions in the cool temperatures of spring are needed for infection by the *Discula* fungus. In some watersheds, nearly all dogwoods have died.
Ecologically, the flowering dogwood plays an important role in the park. Its foliage, twigs and fruits are higher in calcium (2-3%) than almost any other forest species, and it is therefore a prime soil builder. Migratory birds depend on its reliable, high protein fruit in the autumn, and its leaves and twigs are preferred browse for herbivores, from deer to invertebrates.

Park ecologist Mike Jenkins and Dr. Peter White of the University of NC recently co-authored a publication entitled “Dogwood Mortality and Understory Composition Change.” The publication compares dogwood within 87 permanent plots in the western end of the Smokies that were sampled between 1977-1985 and 1995-2000. Within the plots dogwood mortality of up to 93% occurred during this period, with the worst losses in plots with heavier overstory shading that allows dogwood anthracnose to survive. The smaller dogwoods (1-4.9 cm diameter at breast height) suffered the most. In three plots affected by fire, where shading was decreased due to overstory tree loss, the density (stems per hectare) of dogwoods more than doubled. While this may sound like good news the report warns that fire could be damaging to long-term dogwood populations as the trees may not have the energy to resprout after a fire burns their tops.

While the long-term effect of this disease in the park is not fully understood the results of the report are not encouraging. Research shows that the last dogwoods to succumb in a site are the ones in sunny locations. These may survive years after nearby shaded trees are dead. Trees are dying in most watersheds along streams, on northerly slopes and the cooler, moister high elevations of the park. There is no treatment known to be practical, affordable, or environmentally advisable for use in natural zones in the park.

Butternut canker

This stem-canker fungus (*Siroccus clavigigenenti-jugulandacearum*) is believed to have been introduced into the United States around 1960 on the East Coast. Although it can infect black walnut, it has a lethal impact only on butternut (white walnut). Elongate lens-shaped cankers appear on the trunk, limbs, and twigs and even penetrate the immature nut, causing it to abort. This fungus went unnoticed in the southeastern U.S. until about 1986.

Butternut populations are declining, and in 1990 the U. S. Fish and Wildlife Service added butternut to its list of candidates for protection under the Endangered Species Act. The U.S. Forest Service has restricted the harvest of butternuts on lands it manages and is collecting and testing wild butternut genetic material for resistance to the disease.

In September 1987, the park located 70 trees for long term monitoring of tree health. Monitor trees are evaluated every three years. All study trees appear to be infected with butternut canker but some trees that receive full sun are growing vigorously and healing old cankers. Reproduction is restricted to these remaining healthy individuals. Seedlings must have full sun to grow and such conditions require natural disturbance, i.e. floods, treefalls, etc.

In the 1990s the park and the University of Tennessee grafted new twigs (scions) to other rootstock and began screening these seedlings and those grown from collected nuts of our remaining butternuts before the parent trees die. Park collected butternuts are included in four seedling plantations- one in Virginia, one in North Carolina and two in Tennessee (one of which contains 700 trees).

Also at the University of Tennessee, a statistical model was created to predict the location of butternut trees. The model uses site characteristics at locations of known trees. The model was tested at 130 sites in 2001 and proved to be useful at predicting locations of butternut.

Chinese chestnut blight

This Asian disease has eliminated the American chestnut as a full-sized tree from the park. Until the blight arrived in the 1930's, the chestnut was the most common canopy tree at most mid-elevations. Many dead stumps re-sprout because the fungus does not kill the roots, but almost no reproduction from nuts is occurring. Allegheny chinquapins and scarlet oaks are also affected by chestnut blight. In the late 1980s, the park cooperated in a project with the University of Tennessee and the American Chestnut Foundation to produce a disease resistant American chestnut. Cuttings are taken from American chestnuts and grafted onto other rootstock of a highly blight-resistant Asian species, then back-crossed to American parents, in an effort to produce a tree that is close to the native chestnut but retains the blight-resistance genes. This technique has worked for agricultural crops that are usually annuals, but no one has tried it for trees before. The process will take 10-15 years.
A survey to document surviving American chestnut trees was conducted in the park in 2003 and found 288 chestnut trees larger than in diameter, 157 of which were flowering, and 31 were fruiting. Using that location information two university based projects have begun. One involves sampling the cankers on infected trees and screening for hypovirulence- a naturally occurring virus that stops the growth of pathogenic cankers and converts them to superficial wounds. The other project involves creating and field testing a predictive statistical model of where other chestnuts could be found based on locations of known chestnut trees. The model will be refined to give the best prediction of chestnut in the park for future researchers.

Dutch elm disease/Elm yellows

Both of these diseases have been found in the park and dying elms were first noticed along Little River starting in the late 1980's. Dutch elm disease (DED) is a fungal disease that originated in Europe, and is transmitted to American, slippery, and winged elms by elm bark beetles. Elms become especially susceptible to the disease when beetles, carrying the fungus, reach the canopy and start to feed. This is believed to be the second extended outbreak of this disease since the 1950's.

Tree geneticists at the USDA Agricultural Research Service have identified American elms resistant to Dutch elm disease. DED-resistant American elm seedlings should now be available. Elm yellows is a mycoplasma-like organism (MLO) disease transmitted by leafhoppers. Initial visible symptoms of the disease include yellowing of foliage in summer. Elms susceptible to the disease do not recover.

European mountain ash sawfly

This European insect was introduced to Canada sometime in the early 1900’s and was documented in the park in the early 1990’s. It defoliates American mountain-ash, which grows

at high elevations along the crest of the Smokies. The growing season is short at these elevations so any defoliation prevents the production of food and depletes the tree's energy reserves. Long-term monitoring showed an unusually high mortality of mountain ash in the late 1980s, which may be attributable to the European mountain ash sawfly, but the connection is not certain. Heavy defoliation events have not occurred in the park for over a decade.

American beech

Diseased American beech trees were noted at high elevation in the central part of the park in the late 1980's, but no factor was clearly identified as the cause. In September 1993, both the beech bark scale insect, from Europe and the *Nectria* fungus, that together cause beech bark disease (BBD), were found and confirmed to occur in the park. BBD has now killed high elevation beech forests throughout the park and the disease has moved to individual trees at lower elevations. In New England, where BBD was documented in the 1930s, about half of the beech trees are dead or dying, and most of the rest are severely deformed.

Ten long-term monitoring plots were established in 1994 where baseline condition measurements have been recorded for beech and associate species. The plots are evaluated every other year. 2004 evaluations show increased severity of the disease. One plot moderately infected in 1994 now has 100% mortality of the overstory beech (37 trees).
Other areas have varying levels of decline and mortality.

In cooperation with the University of Tennessee (UT) during 1994-1997, beech scale predators, parasitoids, and *Nectria* species identification and biology were studied. No natural controls were found although park-wide a species of predatory mite (an undescribed species) was found feeding on beech scale.

A graduate student at UT studied the genetics of beech in beech gaps during 1998-2000. Her work looked at clonality (identical genes) in beech gaps and at resistance to beech bark disease. Essentially no resistance to BBD was found.

The annual survey of beech scale infestation on American beech along sections of the Appalachian Trail in 2006 showed somewhat less severity of the disease on the western portion of the park. The survey covers about 50 miles of the AT and side trails.

Southern pine beetle (SPB)

This native insect has a major role in the pine forest ecosystems of the south. SPB populations are cyclic and are controlled by native predators and parasites as well as weather patterns. Pines, especially the yellow pine group, cannot reproduce well without some sort of disturbance. Research in the park suggests that pine forests, SPB and fire form an ancient triangle of interaction, in which the beetle dramatically increases dry, resinous fuels in spots on south facing slopes. Fire burns more intensely there, creating the mineral soil "seedbed preparation" required for pine germination.

Park biologists map SPB-killed areas of trees (spots) by air and report findings to state agencies. SPB infestations tend to be cyclic; natural predators, parasites and environmental factors (such as very cold winter temperatures) end outbreaks in a few years. Several years ago mild winters combined with some moisture stress allowed SPB populations to increase and kill susceptible pines. The populations crashed by 2003 and few new attacks have occurred.

One concern with respect to SPB is the decline in occurrence of Table Mountain Pine, *Pinus pungens*, a species that requires fire to open its cones and release seeds. For 60 years, the park suppressed fire so that even when beetle- killed trees provided openings in the tree canopy, no new Table Mountain Pines germinated. The park is now reversing this trend, through prescribed burns and allowing lightning ignited fires in certain zones to burn, to restore natural processes.

Recently several newly introduced exotic pine beetles have been discovered in the US, and the park is cooperating with other federal and state agencies to monitor them for rapid detection and response programs.

Pests of Future Concern:

Gypsy moth

This infamous European import has generally infested the eastern United States as far south as northeastern North Carolina, Virginia (north of Roanoke), and is spreading into the Midwest. Gypsy moth is known for its defoliation of oaks but will feed on nearly 300 species of trees and shrubs. Spot infestations have been discovered all around the park in east Tennessee, western North Carolina and northern Georgia — all of these have been or soon will be eradicated. In 2004 the Tennessee Division of Forestry treated gypsy moth infestations in east Tennessee with the naturally occurring bacterium *Bacillus thuringiensis (Bt)* on 8400 acres in Campbell County, and 6000 acres are proposed for treatment in adjacent Claiborne County (a new infestation). An exotic fungus, Entomophaga maimaiga, has been controlling gypsy moth populations further north for several years, and may now slow the movement of gypsy moth.

In 2006 no male moths were captured in the 140 pheromone traps placed by park Resource Management staff in park campgrounds and picnic areas. The states of Tennessee and North Carolina also place traps for monitoring.

The All Taxa Biodiversity Inventory, a project to identify all life forms in the park, has tallied nearly 1000 Lepidotpera species including 72 species that are new to science and never described before. Gypsy moths would compete with native lepidopterans that feed on forest trees, and non-target impacts are a primary factor in integrated pest management decisions.

Old growth oak stands and other forest types, which have attracted researchers from around the world, are at special risk since they are not as vigorous. A 3-year project to inventory old growth oak forests in the park was completed in 1994. Old growth oak types in the park were measured at 1640 acres.

Asian Long-Horned Beetle (ALB)

This large black beetle with white markings native to China was accidentally introduced to North America through fresh wooden shipping material. Eradication programs in Brooklyn, NY and Chicago have been in place for several years. Initial controls were limited to cutting infested trees and chipping them. In landscapes systemic insecticides are being used as well. This insect is not yet found in natural areas so its potential host trees are unknown. ALB could pose a serious threat to the park's hardwood trees.

Emerald ash borer (EAB)

This small metallic green beetle from Asia was discovered in Michigan in 2002 and has since spread to 3000 square miles in Michigan, and is infesting portions of Ohio and Indiana as well as Windsor, Ontario, Canada. An infestation in Maryland now has a woodland eradication zone of 1800 acres. In June, 2007 three counties in western Pennsylvania were quarantined after two adult EABs were caught during USDA APHIS (Animal and Plant Health Inspection Service) EAB visual surveys.

EAB attacks all ash species. Three species of ash are known in the park with white ash found most commonly. Trees newly infested with EAB are difficult to detect. Infested trees are often visited by woodpeckers that tear into the trunk searching for the EAB larvae. Infested trees can die in 3-4 years after successive years of limb die back. Systemic insecticides have shown some control but are not practical on a forest-wide scale. Controlling firewood movement from infested quarantine areas is important in slowing the spread of this damaging insect.

Sudden Oak Death (SOD)

In 2004 the Park cooperated with the US Forest Service and the TN Dept of Agriculture in conducting emergency surveys for *Phytopthora ramorum*, the non-native pathogen causing a disease known as Sudden Oak Death. SOD was discovered in California in 1995; since then tens of thousands of oaks have been killed. The pathogen can be carried on a wide variety of trees and shrubs common in the nursery trade (including rhododendron, camellias and mountain laurel). In 2004 infected camellias were shipped to southeastern states from a large nursery in California, and plant protection specialists fear the pathogen may spread into natural areas. *P. ramorum* has been found in north Georgia nurseries. Making the jump from the landscape setting to natural areas requires presence of pathogen, available suitable hosts and correct conditions for infection. Surveys were conducted in the park during 2004 and no samples from rhododendron, mountain laurel or oak returned positive for the pathogen. Starting in 2006, a different detection technique involving host leaves contained in mesh bags and secured in flowing streams is being used.

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